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NSF IUSE: Integrating Sociotechnical Issues in Electrical Engineering Starting with Circuits: Year 3

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NSF IUSE Integrating Sociotechnical Issues in Electrical Engineering Starting with Circuits: Year 3

This NSF-funded Division of Undergraduate Education (DUE) Improving Undergraduate STEM Education (IUSE) project aims to integrate sociotechnical issues into *Introduction to Circuits*, typically the first course in electrical engineering (EE) for undergraduate students. To prepare graduates for real-world problems, which are interdisciplinary and involve complex social impacts, instructors must help students address the sociotechnical nature of engineering. Accrediting organizations such as ABET stress the importance of sociotechnical issues and require undergraduate programs to consider global, cultural, social, environmental, and economic factors in student outcomes [1], as do licensing agencies such as the National Society of Professional Engineers (NSPE) [2] and professional societies such as IEEE [3].

However, many engineering instructors have been educated with a deep technical focus, and though many see the value of addressing sociotechnical issues, they have little experience outside of engineering and feel ill-equipped to integrate these topics in the curriculum [4]. In this NSF-sponsored project, we aim to make it easier for engineering instructors to include sociotechnical issues in their *Introduction to Circuits* courses by developing modules with detailed instructional resources each emphasizing a different sociotechnical issue and leveraging fundamental circuits topics. This paper describes our activities during Year 3 of the project.

Methodology

We have developed a suite of modules which integrate technical and social topics related to the *Introduction to Circuits* course. Three of the modules were developed with the collaboration of a cohort of graduate students, our Sociotechnical Electrical Engineering Stars (SEES). Instructors on the project team first tested each module at a small private institution (University of San Diego) and a large public research institution (University of Michigan). Then we enlisted electrical engineering instructors outside of the project team at institutions across the USA to implement our modules. Successful implementation of these sociotechnical modules in a range of different contexts enhances the likelihood of widespread adoption and potential for impacting the field of electrical engineering.

Our research questions include

1. How can graduate students apply proven course design practices to effectively integrate sociotechnical issues into an *Introduction to Circuits* course?
2. What is the impact of the modules on students' sense of social responsibility and their adherence to normative cultural beliefs?
3. To what extent do our course materials assist engineering instructors in implementing sociotechnical modules into their *Introduction to Circuits* courses?

To address our research questions, we are assessing the impact of these modules in multiple ways. We developed a survey evaluating students' attitudes about sociotechnical issues in engineering which we administer at the beginning and end of the semester in courses that use a module [5]. In those same courses we conduct interviews of students and instructors about their experiences. Beginning in January 2025, we collect exit ticket survey data at the end of each

class period when a module is implemented to obtain immediate feedback. We are continuing to analyze this data.

Results and Activities for Year 3 (2025)

In year 3 of this project, we piloted three modules developed by the SEES cohort in Spring 2025, facilitated a panel about the experiences of our SEES cohort and a workshop to introduce other instructors to our modules in Summer 2025, and supported instructors across the USA in implementing our five modules in Fall 2026. We also presented our work at several international venues.

Modules

For this project, five sociotechnical modules have now been developed, piloted, and implemented. Brief descriptions are provided in Table 1.

Table 1 *Modules that have been developed, piloted, and implemented*

Topic	Circuits Content	Social Issues
Conflict Minerals	Capacitors	Mineral sourcing, Mining conflict minerals in the Democratic Republic of the Congo (DRC)
EV Batteries	Voltage divider with load	Circular economy, issues related to EV battery life
Energy Burden	Power vs energy, calculating power	Energy insecurity, efficiency, LED vs lightbulb
Energy Efficiency	Power vs energy, calculating power	UN Sustainable Development Goals, efficiency, LED vs lightbulb
Power Prioritization in Hospitals	Series and parallel circuits, equivalent, circuits calculating power	Red outlets in medical settings, deciding which branches to load shed

Sociotechnical Electrical Engineering Stars (SEES) Panel

To share information about the experiences of the SEES cohort, we facilitated a panel discussion at the 2025 ASEE Conference in Montreal, Canada [6]. Two of the graduate student SEES cohort members presented in person and three over zoom. To ensure equitable participation, all five presenters submitted short videos addressing insights from developing the modules and suggestions for instructors implementing these modules which were shown during the panel. Based on questions from the audience and comments from students during piloting of modules, we invited the module developers to prepare brief videos about their background and motivation for their modules. These videos enable students to see a range of people in electrical engineering and experiences including working in the utility industry in Panama, an internship in Gabon Africa, and a doctoral project on energy use in underserved communities. These videos are now available for instructors to incorporate into their facilitation of the modules in their courses.

Workshop at ASEE 2025 and Module Testing in Fall 2025

We facilitated a workshop at the ASEE Annual Conference in 2025 "Sociotechnical Modules for the Introduction to Circuits course," sponsored by the Electrical and Computer Engineering (ECE) Division with 29 attendees. We began with introductions and goals of the workshop followed by an overview of this NSF project and guidelines for developing modules. Then one of our SEES cohort module developers presented her Power Prioritization Module so participants could experience a module and then discuss and debrief the experience. We then provided an overview of the other four modules that have been tested. One of the PIs and another professor who implemented two modules in her course provided some tips on using the modules. Next steps for those interested in implementing the modules were shared. The workshop ended with participants dividing into small groups to discuss specific modules or to identify challenges and necessary steps to implement a sociotechnical module in their courses. We provided a link to a google form to determine eligibility to implement one of our modules in the 2025-2026 academic year.

Eligibility requirements included

- Teaching an introduction to circuits class in 2025-2026
- Agreeing to
    - Administer pre/post survey
    - Teach module in class and do exit ticket survey
    - Add homework and/or exam problems related to module
    - Advertise opportunity for students to do compensated zoom interviews
    - Participate in an interview

Twenty instructors completed our eligibility survey including seven who attended our workshop and thirteen who did not. From this pool, we assigned specific modules for six instructors for Fall 2025, one for the intercession, and seven for Spring 2026.

To be sure that all participants were prepared, the two PIs of the project developed and facilitated a one-hour training session for instructors using our modules building on lessons learned from the workshop at ASEE. Before the training, we sent information about the project and modules and a link to a recording of a module. During the online workshop, topics included introductions, an overview of this NSF project, expectations for faculty partners, and tips on using the modules. These tips, from the PIs and others who have implemented the modules, include review the entire teaching guide, customize as needed, include sociotechnical material on homeworks and exams, use active learning, and plan how you will introduce the module. Then we had a discussion of the instructors' experiences reviewing the module, and next steps. In Fall 2025, instructors around the USA tested our modules. A summary is provided in Table 2. Interviews with these instructors are being conducted in Spring 2026, and feedback will be used to inform future improvements to the modules and the training materials.

Table 2 Modules tested in Fall 2025

Topic	Institution
Conflict Minerals	Bucknell University, California Polytechnic, San Luis Obispo (SLO)
EV Batteries	Mississippi State University
Energy Burden	University of Virginia
Energy Efficiency	University of Florida
Power prioritization in Hospitals	Bucknell University

Dissemination

In year 3, we shared our work with the larger international engineering education community at several conferences. At the IEEE EDUCON conference in London, United Kingdom, we presented an overview of the modules developed by the SEES cohort [7] and highlighted results from this project in an invited plenary talk on "Real World Engineering" Integrating Ethics into Electrical Engineering Education [8]. At the 2025 ASEE Conference in Montreal, Canada, we presented at the NSF Grantees session [9] and a paper about the SEES cohort [10]. At the 2025 European Society for Engineering Education (SEFI) Conference in Tampere Finland, we presented results from implementing the conflict minerals and EV batteries modules at two universities [11]. At the 2025 Frontiers in Education conference in Nashville, TN, USA we presented results from piloting modules developed by the SEES cohort and student response to implementing modules at two universities [12, 13]. We published a journal paper in *Education Sciences* about the use of our conflict minerals module in a large class taught by an instructor who is not on the project team [14].

Our work was enthusiastically received at these venues with several people indicating a desire to receive updates about our modules and stay informed through an electronic interest form tinyurl.com/circuits-modules. As of January 20, 2026, our interest list includes 137 people.

Summary

Table 3 shows an overview of our research questions, activities and data collected and outcomes for the project through December 2025.

Table 3 Overview of Project

Research Question	Activities and Data	Outcomes
1. How can graduate students apply proven course design practices to effectively integrate sociotechnical issues into an *Introduction to Circuits* course?	• Facilitated SEES Cohort Program • Interviews with cohort	• 3 modules developed by SEES cohort • Lessons learned shared in ASEE paper [10] and ASEE panel [6] • Graduate students felt supported and valued the collaboration from cohort and PIs. Challenges included time constraints, effectively integrating technical and social elements and creating content for students and instructors.

2. What is the impact of the modules on students' sense of social responsibility and their adherence to normative cultural beliefs?	• Implemented 5 modules at various institutions • Student interviews • Student surveys • Exit Tickets (added in January 2025)	• Student interview findings for several offerings have been shared in multiple venues including [11, 14]. • Overall, students found the module to be valuable and relevant, with many noting that it helped them understand real-world engineering practice. While some expressed concern about adding new material to an already content-heavy course, more than half agreed that this type of content is important and that they would like to see more sociotechnical topics in their engineering courses. [14] • Students responded positively overall to including social issues in technical classes. Students discussed how such content helped them learn, prepared them for their future careers as engineers, and was important to them personally. Most would like to see relevant social issues incorporated into other technical classes. [11] • Surveys shared in FIE [5] and EDUCON [15] • Students perceive public welfare as central to the engineering profession, that social and ethical dimensions are critically important in individual engineering work, and that social factors have a meaningful influence on career choices. These findings demonstrate that engineering students are open to integrating social issues into their studies and future professional roles. The findings challenge common perceptions of engineering student apathy toward social responsibility.
3.To what extent do our course materials assist engineering instructors in implementing sociotechnical modules into their *Introduction to Circuits* courses?	• Instructor interviews (ongoing) • Workshop at ASEE 25 • Training session for instructors	• Instructors find materials helpful particularly the slides, homework problems, video of instructor. • Some instructors were looking for sociotechnical material to integrate into their classes and really appreciated these detailed materials. • Instructors adapted our course materials to fit with online asynchronous offering, different lengths of class periods, and often added their own experiences and emphases. • (analysis ongoing)

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